HarborSym

A Data-Driven Monte Carlo Simulation Model of Vessel Movement in Harbors

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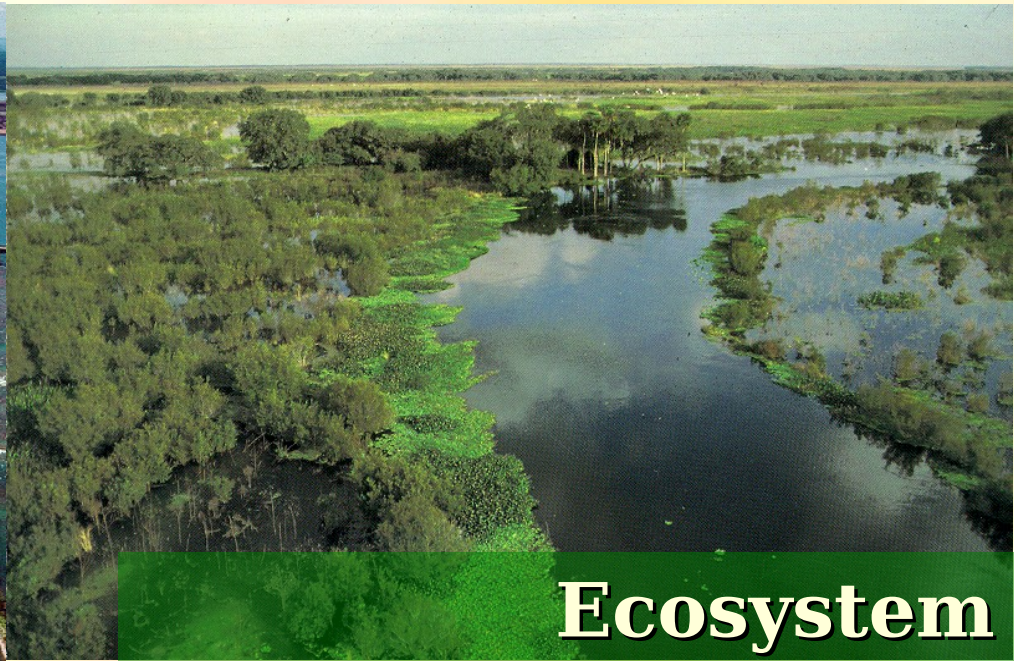
CORPS OF ENGINEERS



Coastal Navigation

- *Benefit-cost analysis* required
- Navigation project benefits:
  - Reduction in congestion *(transportation cost)*
  - Compare future conditions
  - 50 year analysis
- Standardized, transparent tools

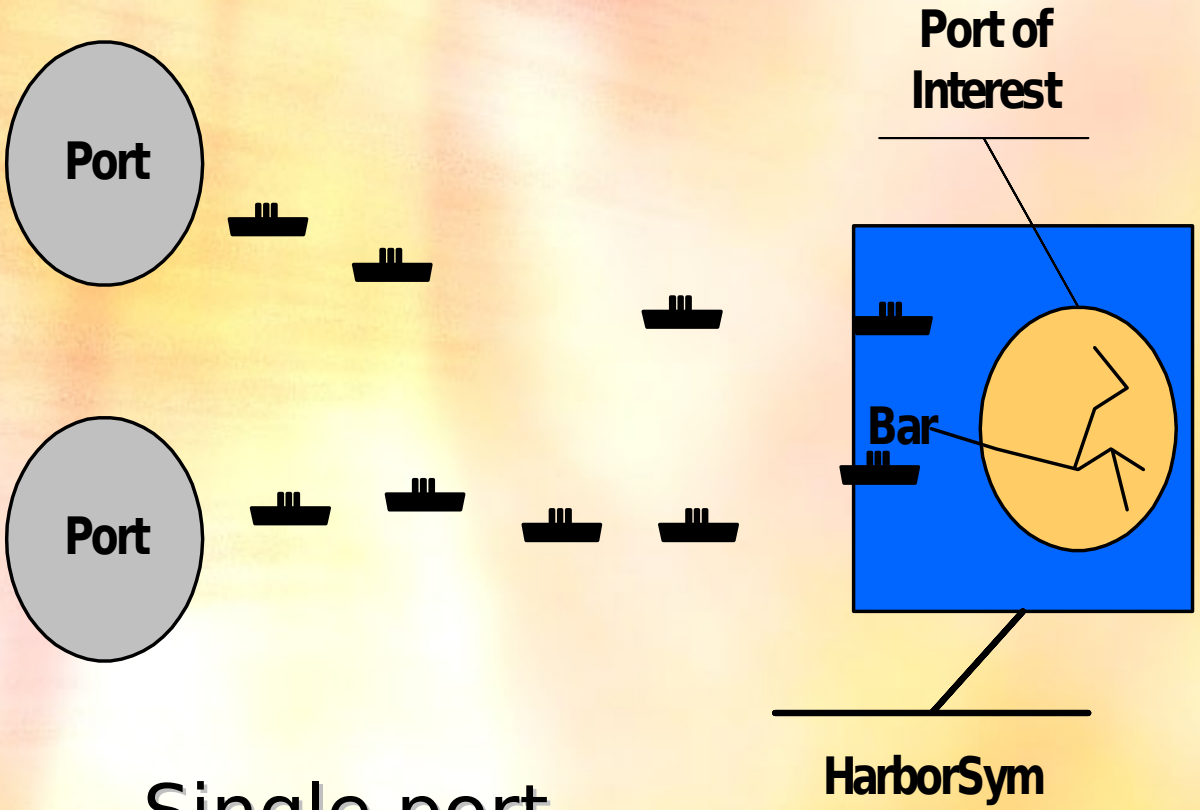
Need for Navigation Modeling

Photo credit: Containerisation International/Lloyds List/Informa UK Ltd

<u>Complex Problem</u>

- Channel width & depth constraints
- Multi-port issues
- Conflicts from random interactions

Navigation Modeling



- Single port
- Focus on channel improvements

HarborSym Model

- Planning-Level Model
- Data Input
  - Port layout
  - Vessel Calls
  - Rules
- Model Calculation
  - Vessel interactions within harbor
- Output
  - Time in system
  - Delay times

HarborSym Modeling Objectives

PORTABILITY

- Port specific information provided in data

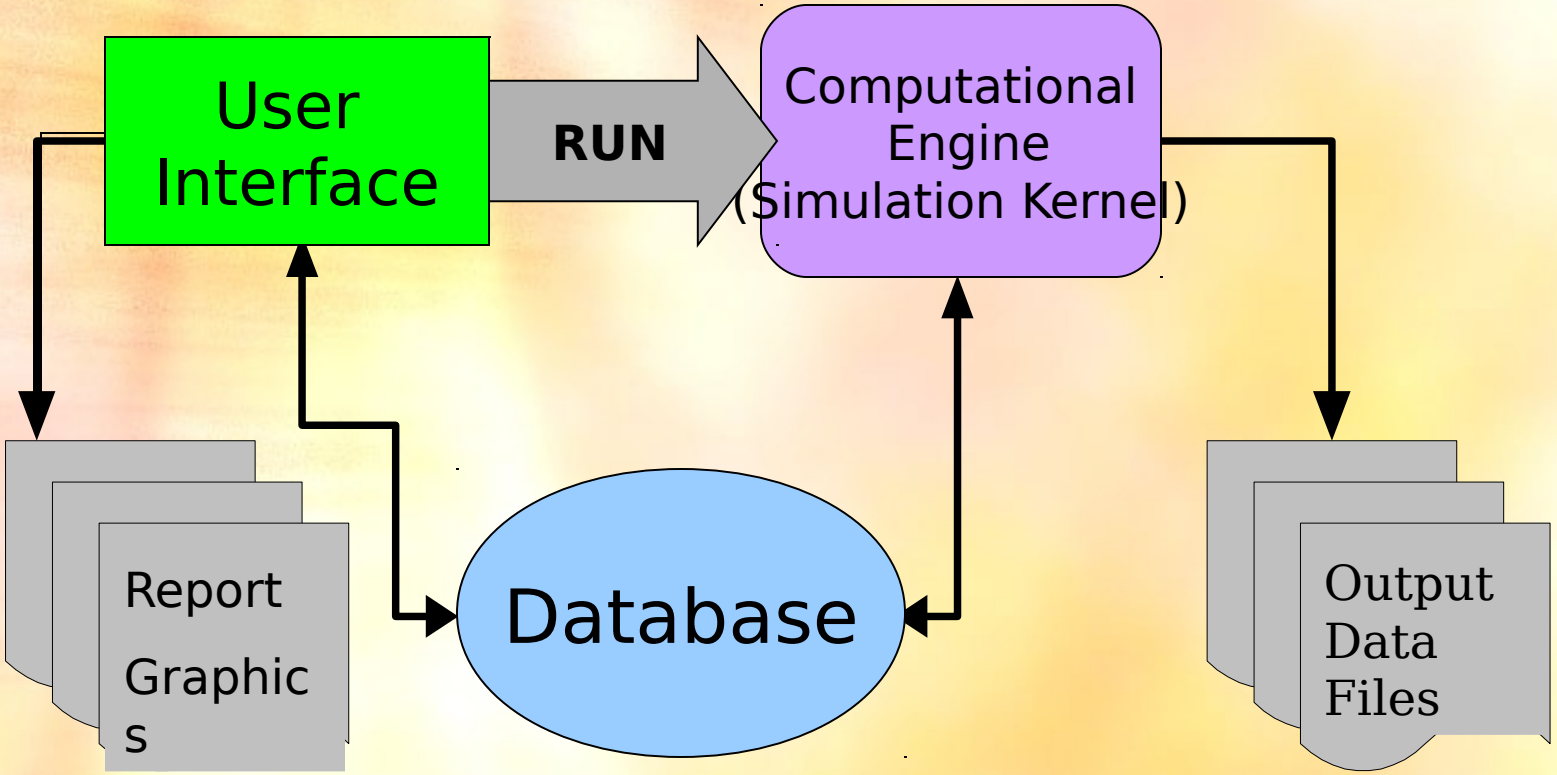
EASE OF USE

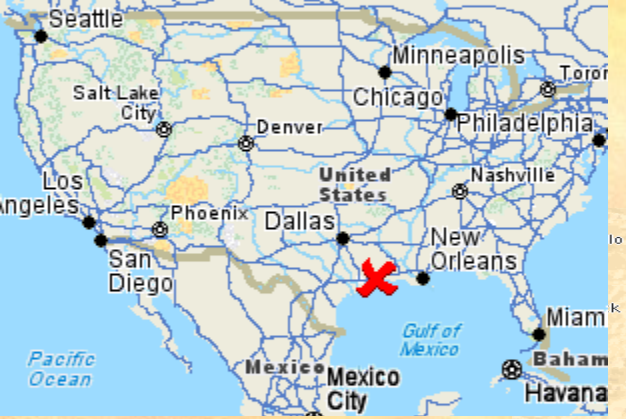
- Discrete Event Monte Carlo Simulation Model
- C++ / Microsoft Access / Visual Basic

TRANSPARENCY

- Windows into delay calculations

HarborSym Architecture





HarborSym Application

Sabine-Neches Waterway

Sabine Network

NODES

- Docks
  - 133 actual docks
  - 11 “virtual” docks
- 10 Turning Basins
- Channel Dimensions
- Proposed Improvements

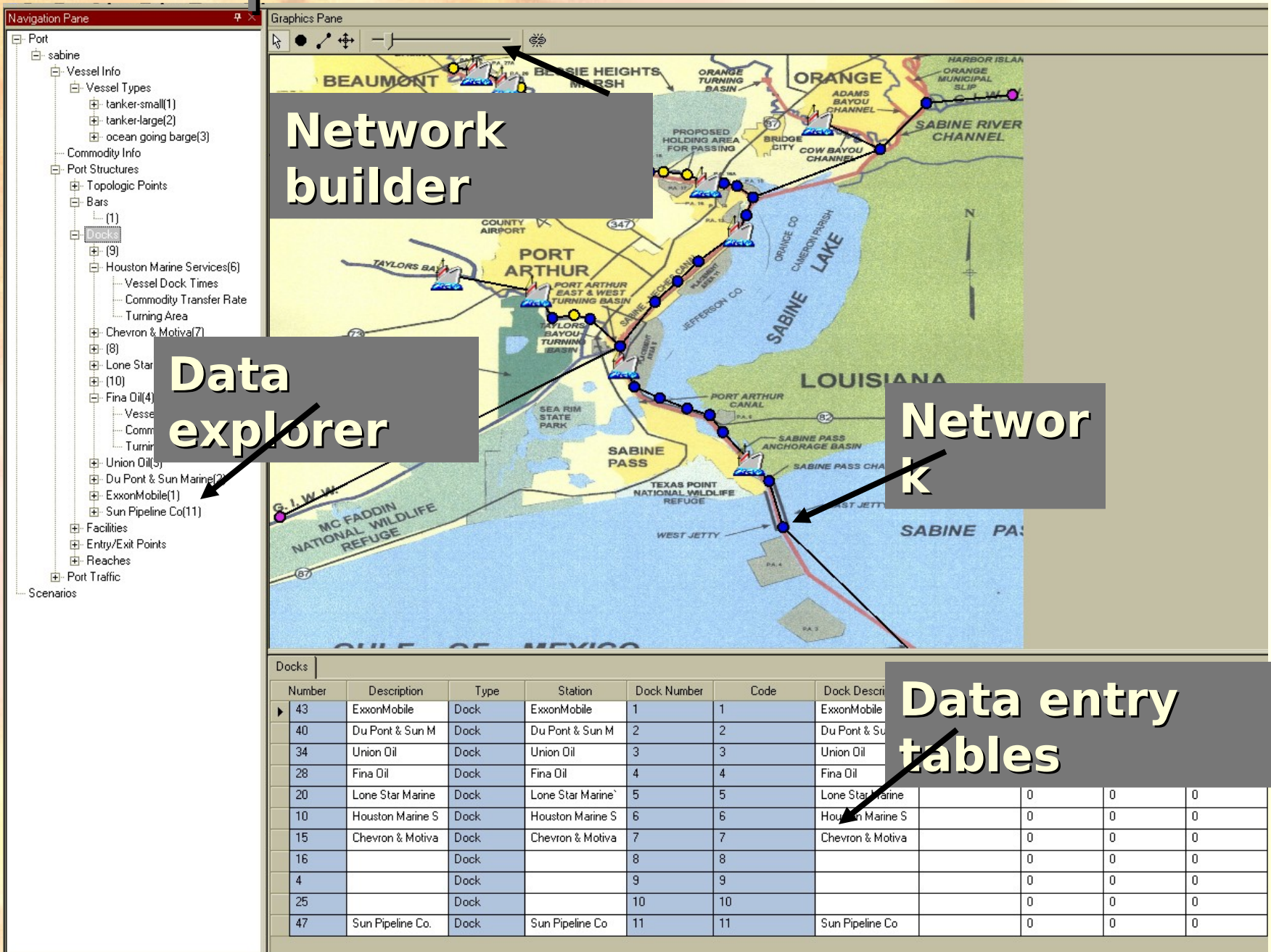
REACHES

- Single route connecting nodes
- Uniform dimensions
- TOTAL: 47

LEG

- Contiguous reaches

Graphical User Interface



Number	Description	Type	Station	Dock Number	Code	Dock Descri				
43	ExxonMobile	Dock	ExxonMobile	1	1	ExxonMobile				
40	Du Pont & Sun M	Dock	Du Pont & Sun M	2	2	Du Pont & Su				
34	Union Oil	Dock	Union Oil	3	3	Union Oil				
28	Fina Oil	Dock	Fina Oil	4	4	Fina Oil				
20	Lone Star Marine	Dock	Lone Star Marine`	5	5	Lone Star Marine		0	0	0
10	Houston Marine S	Dock	Houston Marine S	6	6	Houston Marine S		0	0	0
15	Chevron & Motiva	Dock	Chevron & Motiva	7	7	Chevron & Motiva		0	0	0
16		Dock		8	8			0	0	0
4		Dock		9	9			0	0	0
25		Dock		10	10			0	0	0
47	Sun Pipeline Co.	Dock	Sun Pipeline Co	11	11	Sun Pipeline Co		0	0	0

Sabine Transit Rules

- No sailing (single vessel)
  - by DWT, length, beam
- No meeting (multi-vessel)
  - by DWT, length, breadth, draft, combination
- No overtaking (multi-vessel)
  - by vessel type

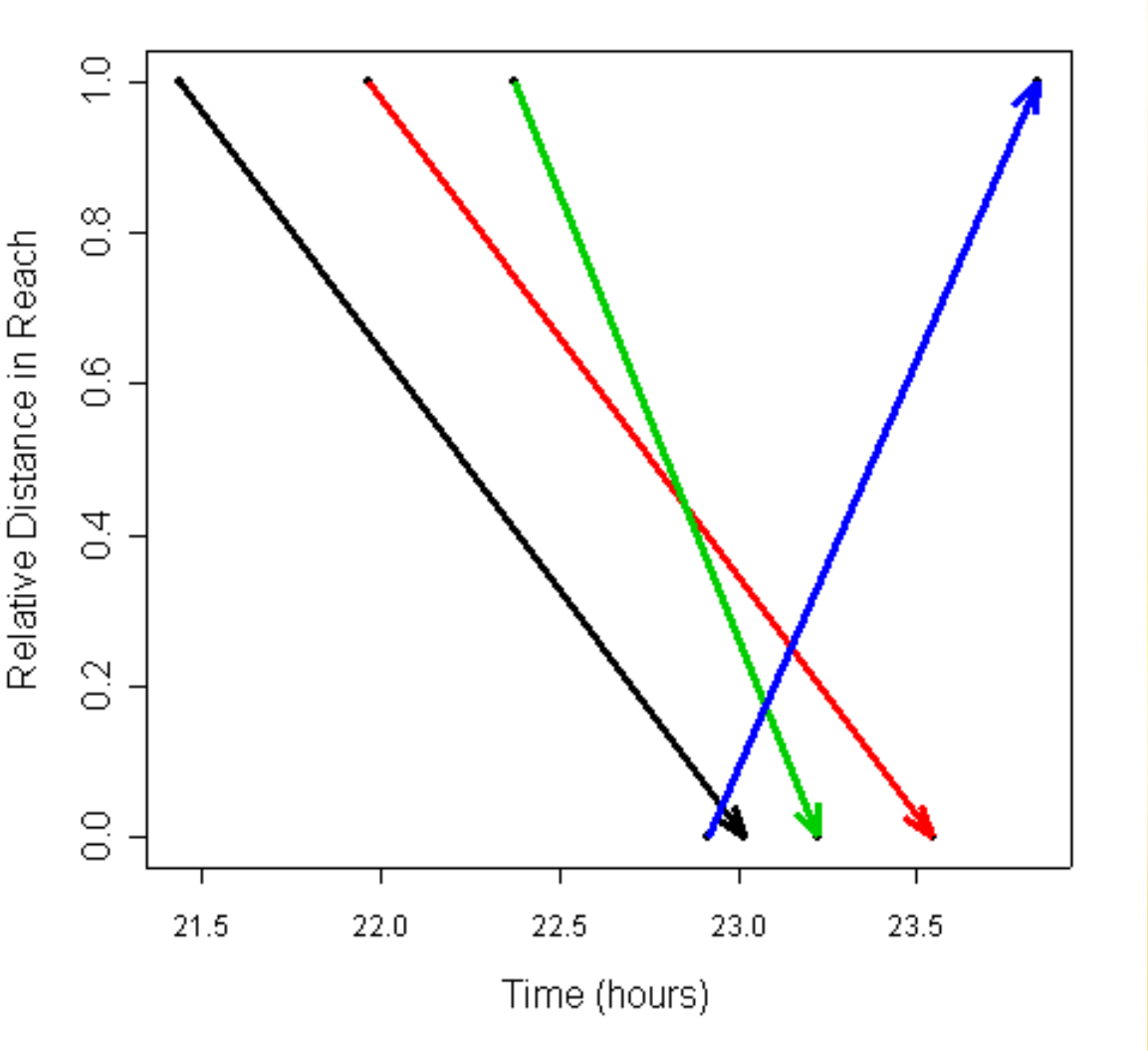
Generic Transit Rules

Transit Rule Type ID	Transit Rule Type	Transit Rule Type Description
1	No Rule	No Transit Rule
2	No Meeting Combined Beam Width	No Meeting - Max Combined Beam Width > 1/2 channel width
3	No Meeting Combined Draft	No Meeting - Combined Draft
4	No Meeting DWT Draft	No meeting – dwt/draft: Max DWT OR Max draft
5	No Meeting DWT Draft Either	no meeting - either vessel with dwt and draft greater than values

Model Processing Logic

1. Vessel Arrival (departure) Event
   - Must pass all transit rules in leg to proceed
2. Conflict Checking
   - Store projected arrival/departure time of vessels in system (by reach)
   - Test rules in all leg reaches
   - Vessels already moving have priority
3. If conflict occurs:
   - Wait, try again
   - Proceed to anchorage

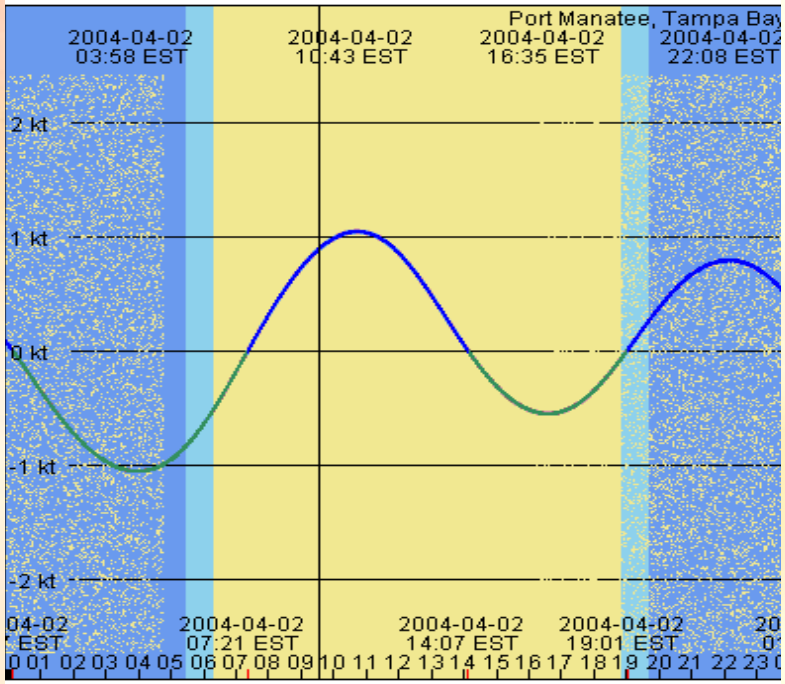
Testing Conflicts in Reach



Additional HarborSym Features

Tidal Influence

- Height of water
- Strength of current

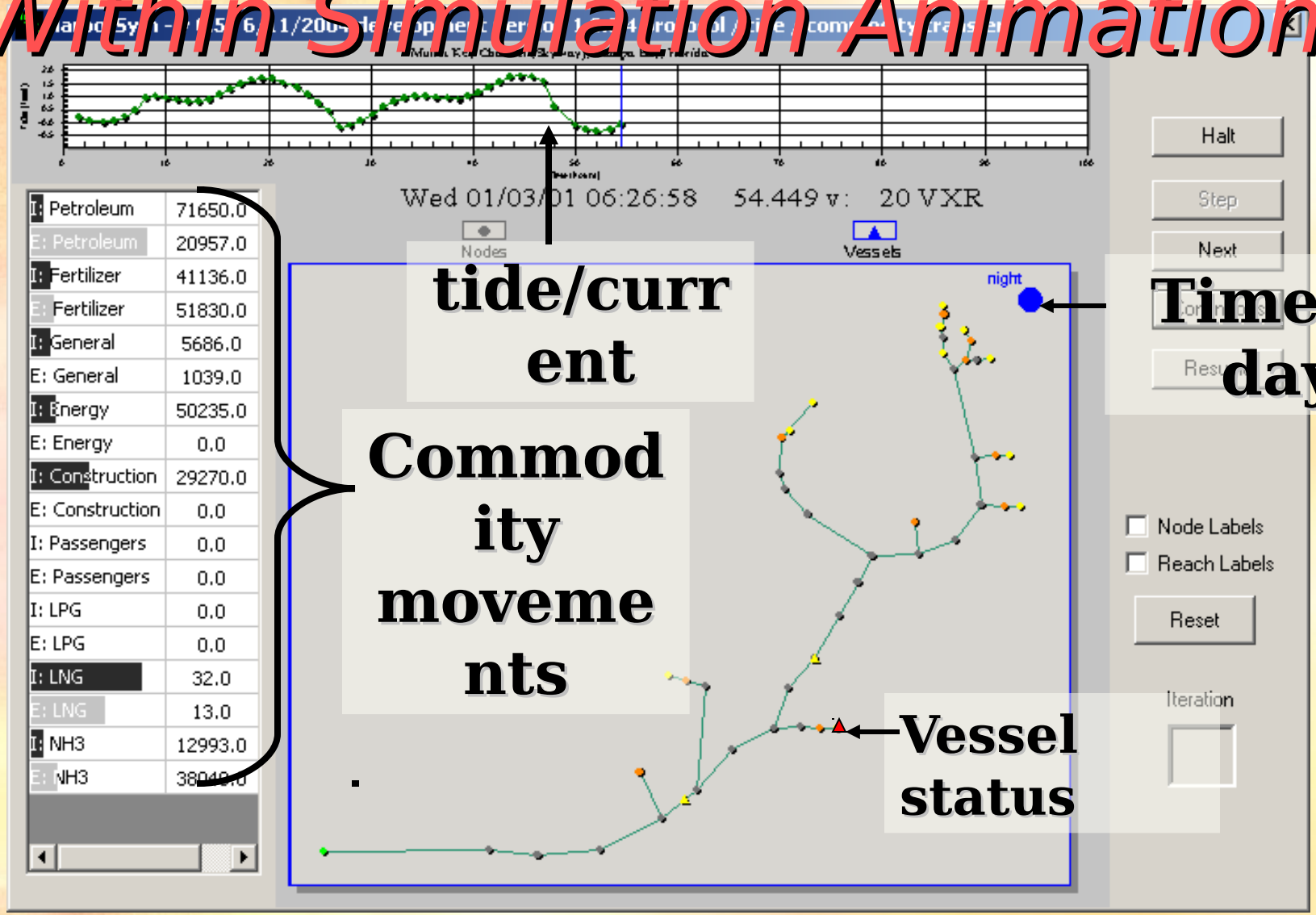


Priority Vessels

- Move unrestricted through harbor
  - Cruise Ships, Gaseous Tankers
- Others anticipate arrival & face delay

Additional HarborSym Features

Within Simulation Animation



HarborSym Output

Capturing Widening Benefits

Average Vessel Times Under Proposed Channel Improvements

	Existing Condition	Intermediate Improvement	All Improvements
Avg Ves Time in System	71.202	70.2	68.8
Avg Ves Time Waiting	10.2	9.2	7.9
Avg Ves Time Wait Entry	3.9	2.8	2.5
Avg Ves Time Wait Dock	4.9	5	2.7

Time in hours, results from 100 iteration simulation.

HarborSym Output

Capturing Widening Benefits

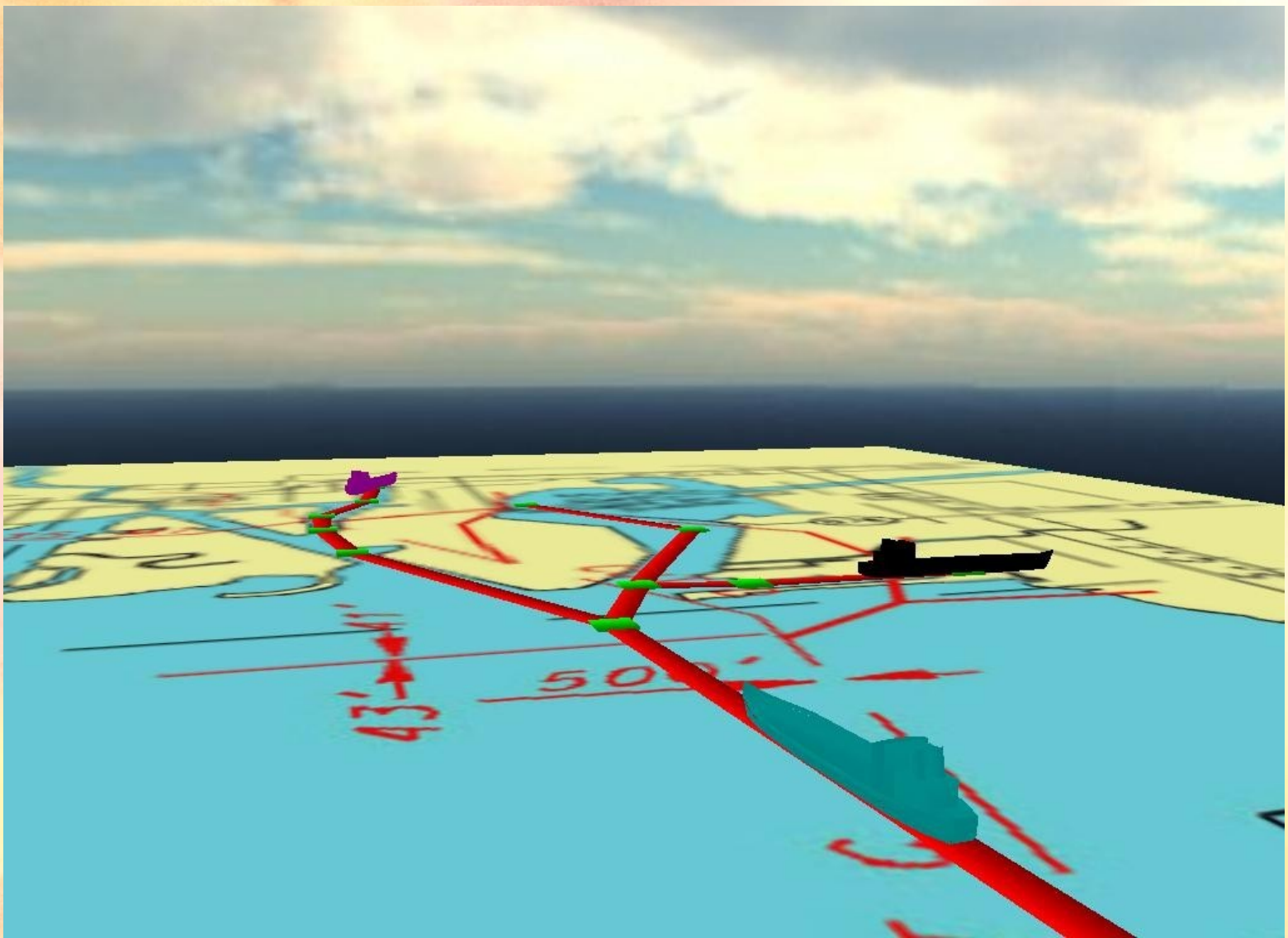
Transportation Cost and Incremental Benefits

	Total Annual Transport Cost (US$1000)	Total Annual Benefit (US$1000)
Existing Condition	$110,635.90	
Intermediate Improvement	$109,199.60	$1,436.30
All Improvements	$107,442.10	$3,193.80

Figures shown in 2002 dollars, based on 100 iteration simulations

HarborSym Output

Post Process Animation



Discussion